

Palomar Transient Factory Pipeline

Peter Nugent (LBNL/UCB) aka TBD

PTF (2009-2012), iPTF(2013-2016)

- CFH12k camera on the Palomar Oschin Schmidt telescope
 - 7.8 sq deg field of view, 1" pixels
 - 60s exposures with 15-20s readout in r, g and H-alpha
 - First light Nov. 24, 2008.
 - First useful science images on Jan 13th, 2009.
- 2 Cadences (Mar. - Nov.) 2009-2011
 - Nightly (35% of time) on nearby galaxies and clusters (g/r)
 - Every 3 nights (65% of time) on SDSS fields with minimum coverage of 2500 sq deg. (r) to 20th mag 10-sigma
 - H-alpha during bright time (full +/-2 days)

Nov-Feb, minute cadences on select fields.

Supernovae circa 2009

Discovery and Follow-up



Instrumentation, system
design, first results

Law, Kulkarni, Dekany et al. 2009 PASP 121 1395L

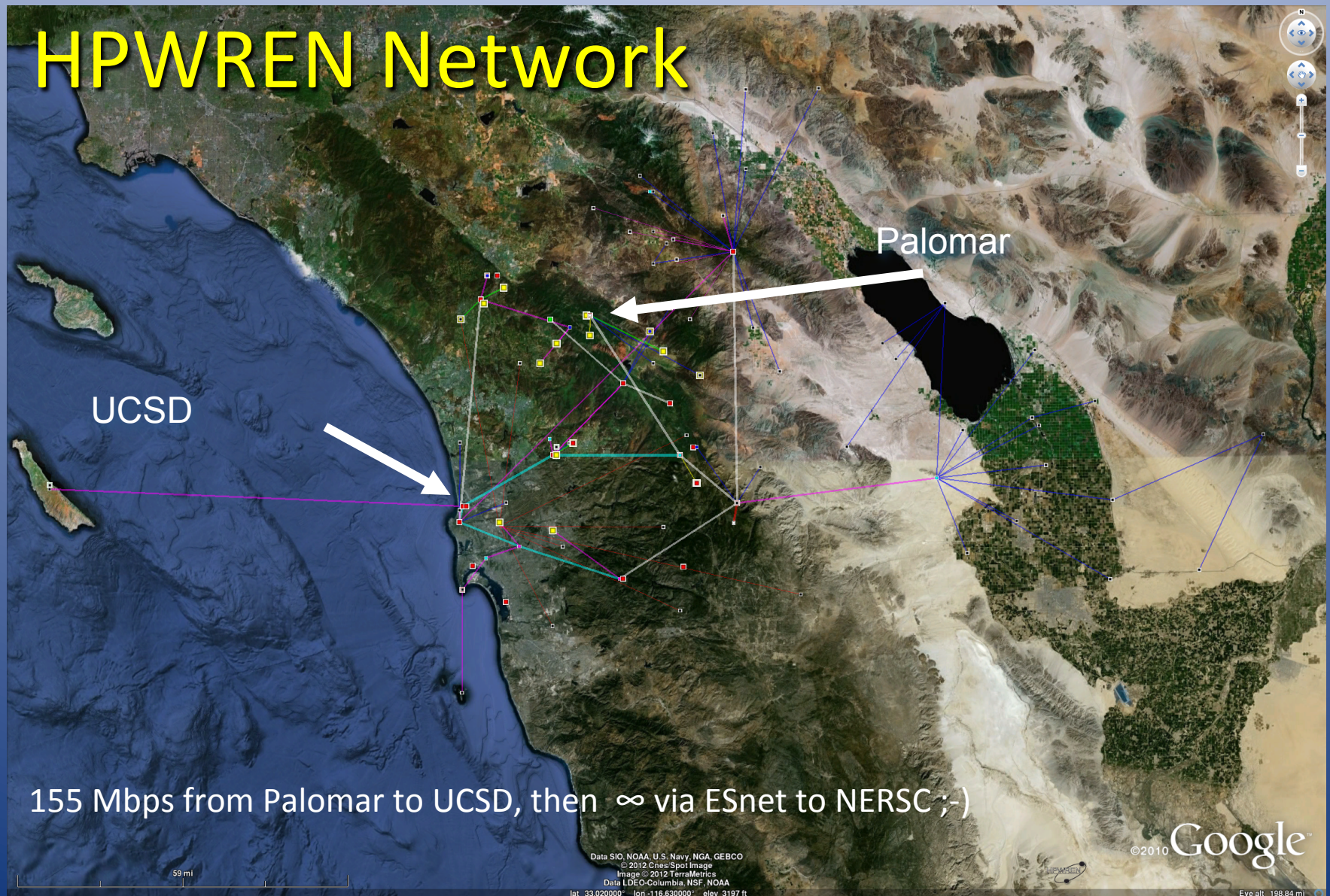
Science plans

Rau, Kulkarni, Law et al. 2009 PASP 121 1334R

2010 survey status

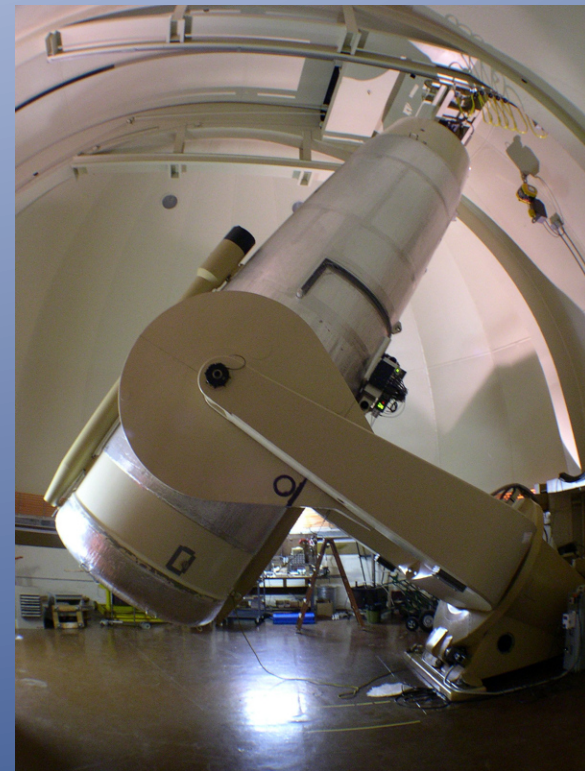
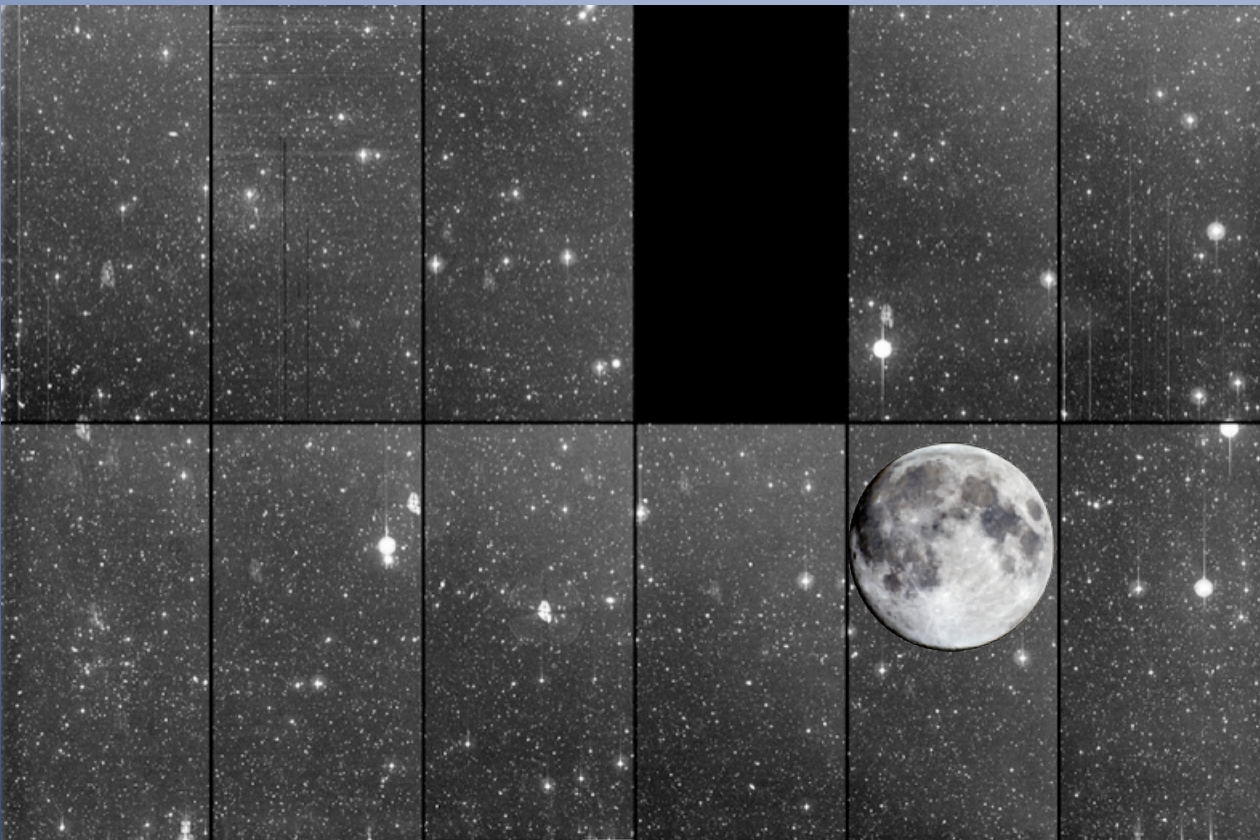
Law et al. 2010 SPIE 7735
Data Processing in Cosmic Frontier

HPWREN Network



155 Mbps from Palomar to UCSD, then ∞ via ESnet to NERSC ;-)

PTF Camera



92 Mpixels, 1" resolution, R=21 in 60s

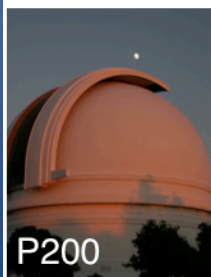
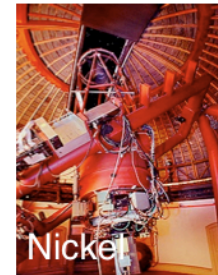
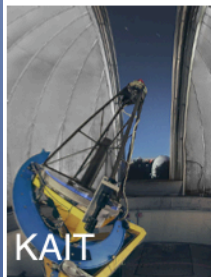
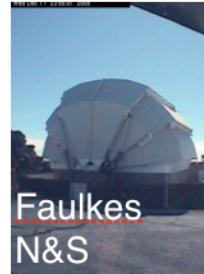
PTF Science

PTF Key Projects	
Various SNe	Dwarf novae
Transients in nearby galaxies	Core collapse SNe
RR Lyrae	Solar system objects
CVs	AGN
AM CVn	Blazars
Galactic dynamics	LIGO & Neutrino transients
Flare stars	Hostless transients
Nearby star kinematics	Orphan GRB afterglows
Type Ia Supernovae	Eclipsing stars and planets
Tidal events	H-alpha 1/2 sky survey

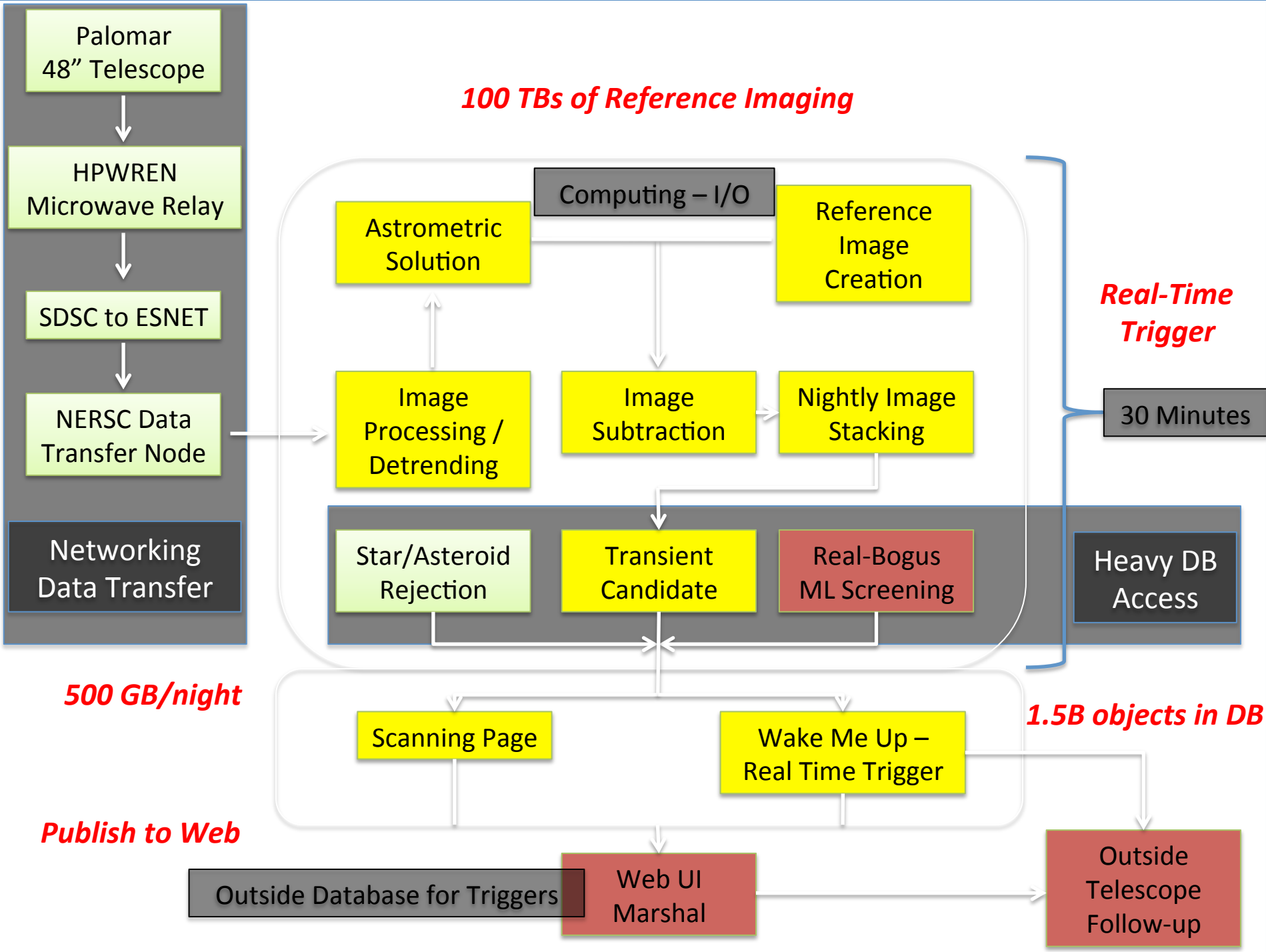
The power of PTF resides in its diverse science goals and follow-up.

PTF Science

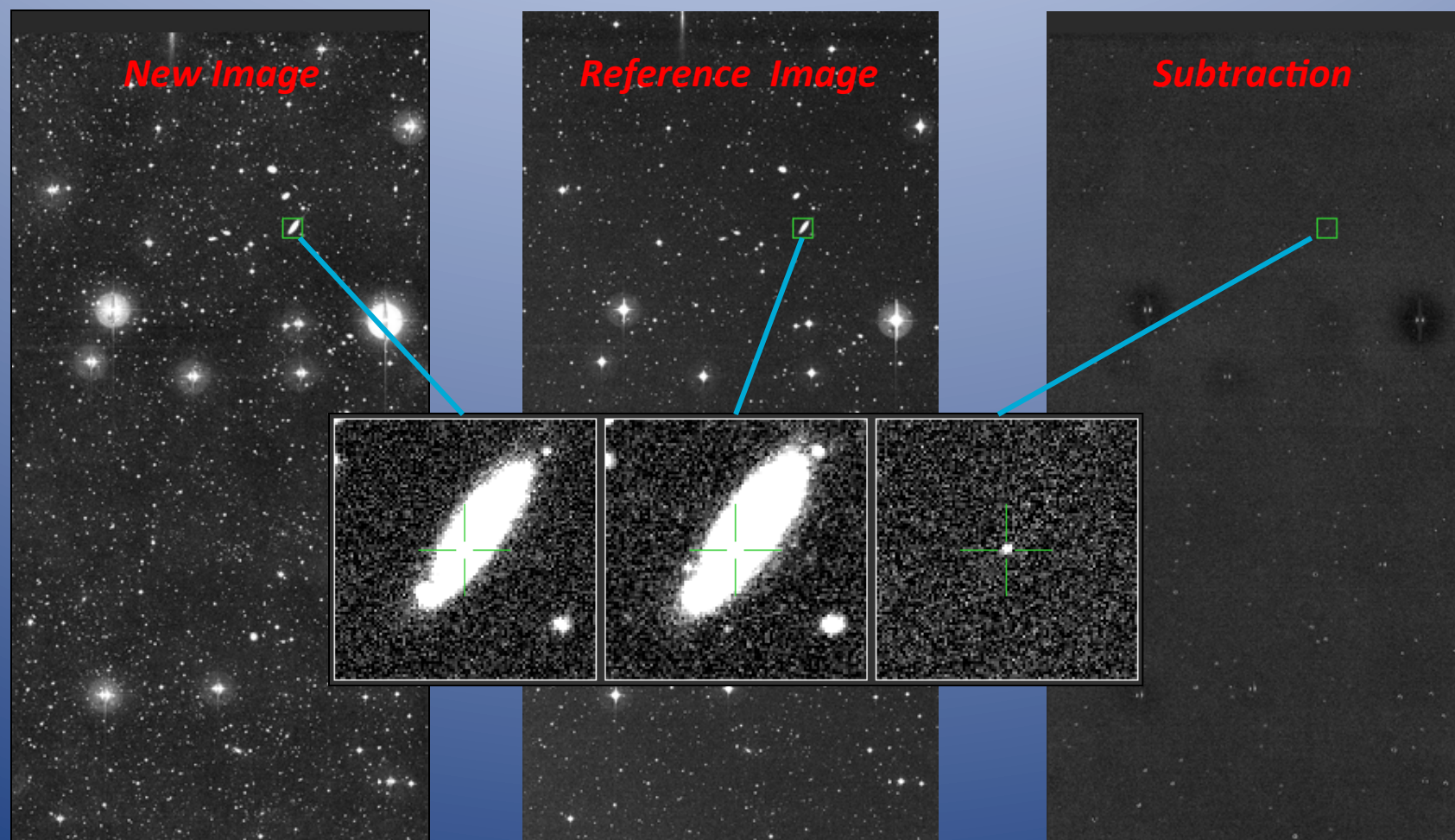
▼► Detected transients will be followed up using a wide variety of optical and IR, photometric and spectroscopic followup facilities.



The power of PTF resides in its diverse science goals and follow-up.



Real or Bogus – Machine Learning Analysis



4096 X 2048 CCD images - over 3000 per night – producing 1.5M bogus detections, 50k known astrophysical objects and only 1-2 new astrophysical transients of interest every night. Machine learning is used to wade through this sea of garbage.

Data Processing in Cosmic Frontier

PTF Database

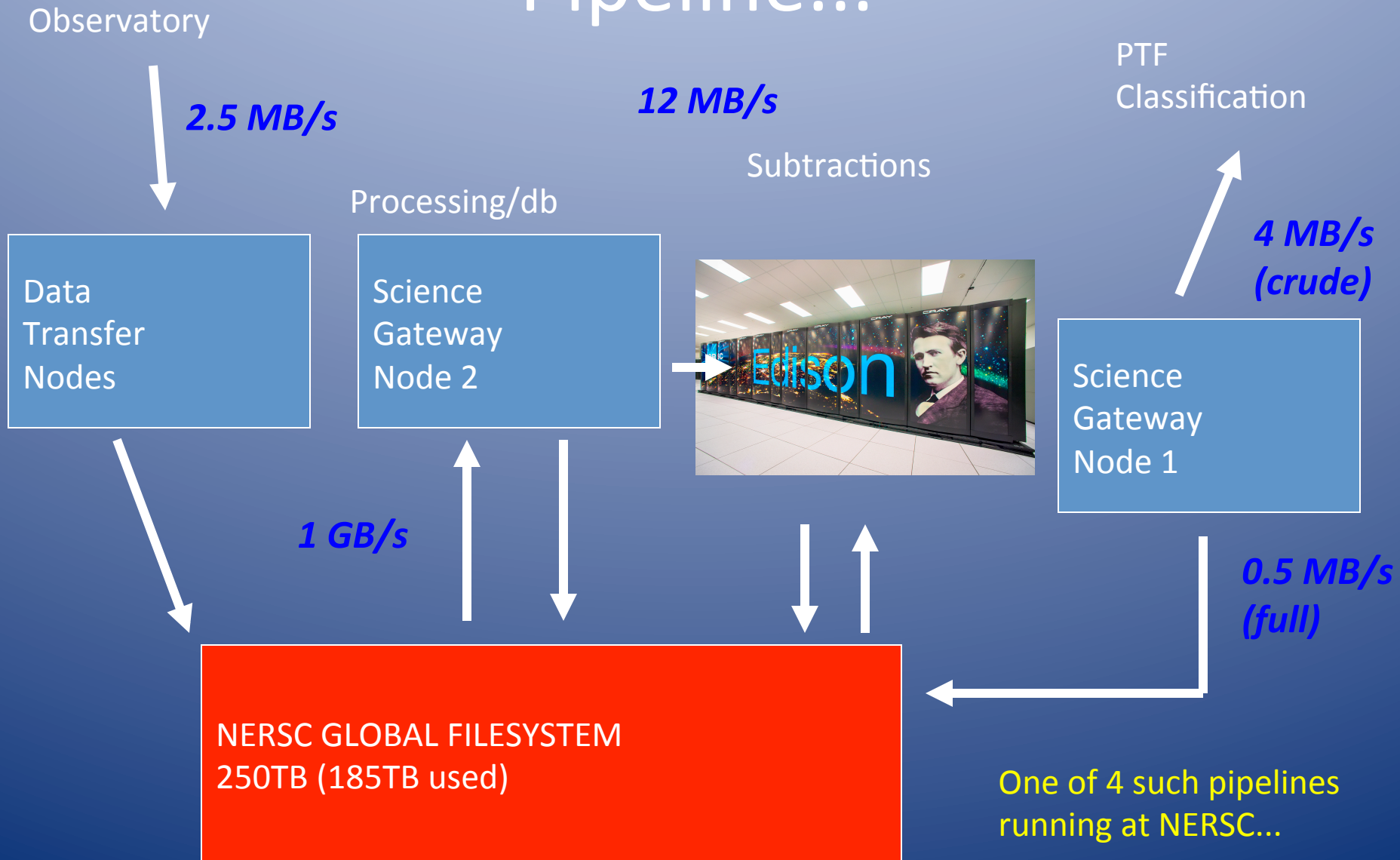
	R-band	g-band
images	1.82M	305k
subtractions	1.52M	146k
references	29.2k	6.3k
Candidates	890M	197M
Transients	42945	3120

All in 851 nights.

An image is an individual chip (~ 0.7 sq. deg.)

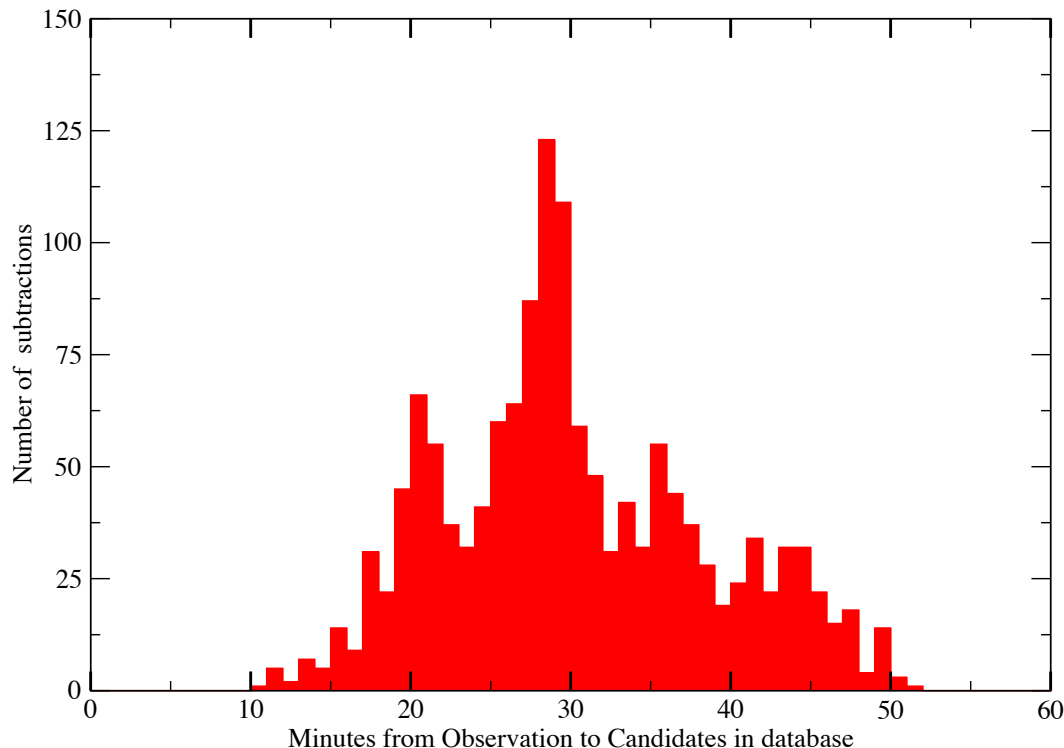
The database is now 1 TB.

Pipeline...



PTF Turn-around

Typical night: 2012-07-06

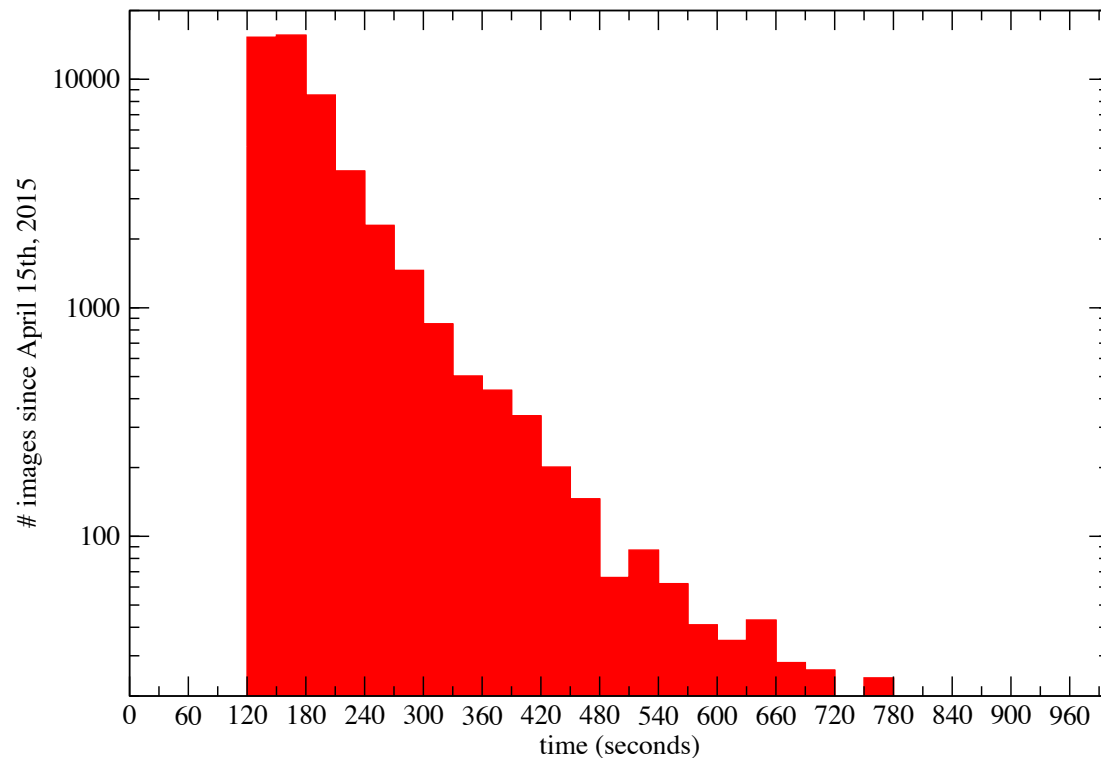


What does “real-time” subtractions really mean?

For 95% of the nights all images are processed, subtractions are run, candidates are put into the database and the local universe script is run in < 1 hr after observation.

Median turn-around is 30m.

iPTF turn-around



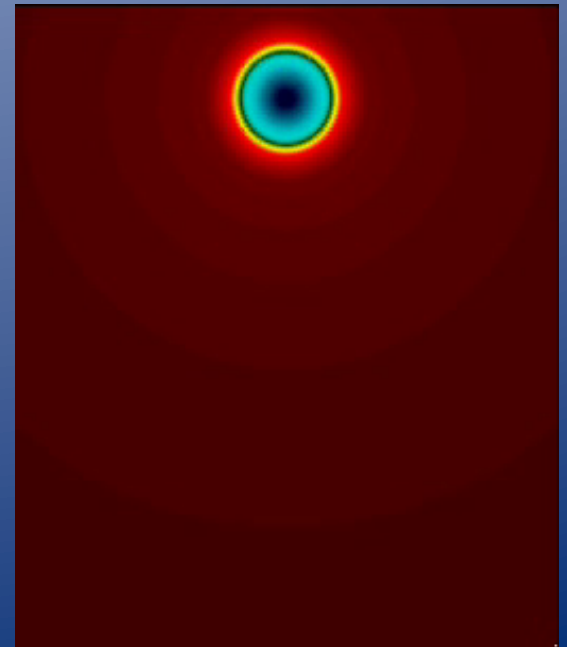
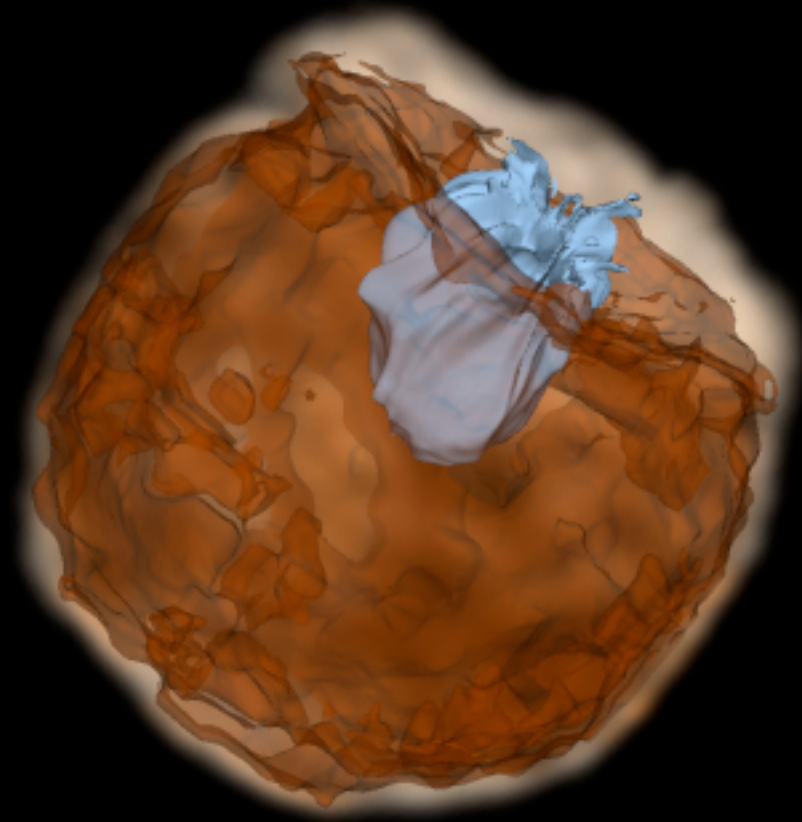
Due to the X-SWAP project (Extreme-Scale Scientific Workflow Analysis and Prediction), funded through the ASCR LAB-1088 call (Analytical Modeling for Extreme-Scale Computing Environments), we have been able to understand and eliminate a lot of our inefficiencies and decrease the turn-around by an order of magnitude!

Better use of the Lustre filesystem (for everything), better use of OpenMP in all codes, reserved nodes, etc.

Discoveries

Yi Cao, et al. (2015) *Nature*,
“A strong ultraviolet pulse
from a newborn Type Ia
supernova”

Predicted in Kasen (2010)
who ran a large set of 3-D
SN simulations of SNe
interacting with a variety
of companion stars.

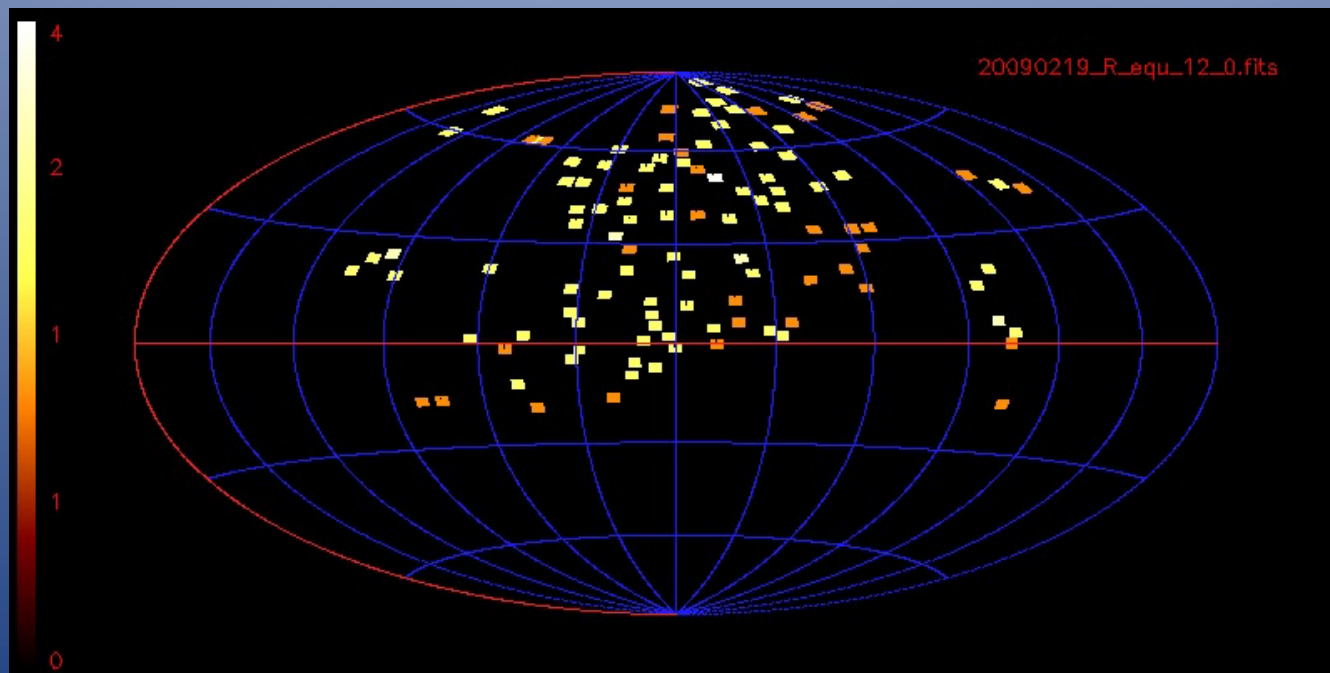


PTF Sky Coverage

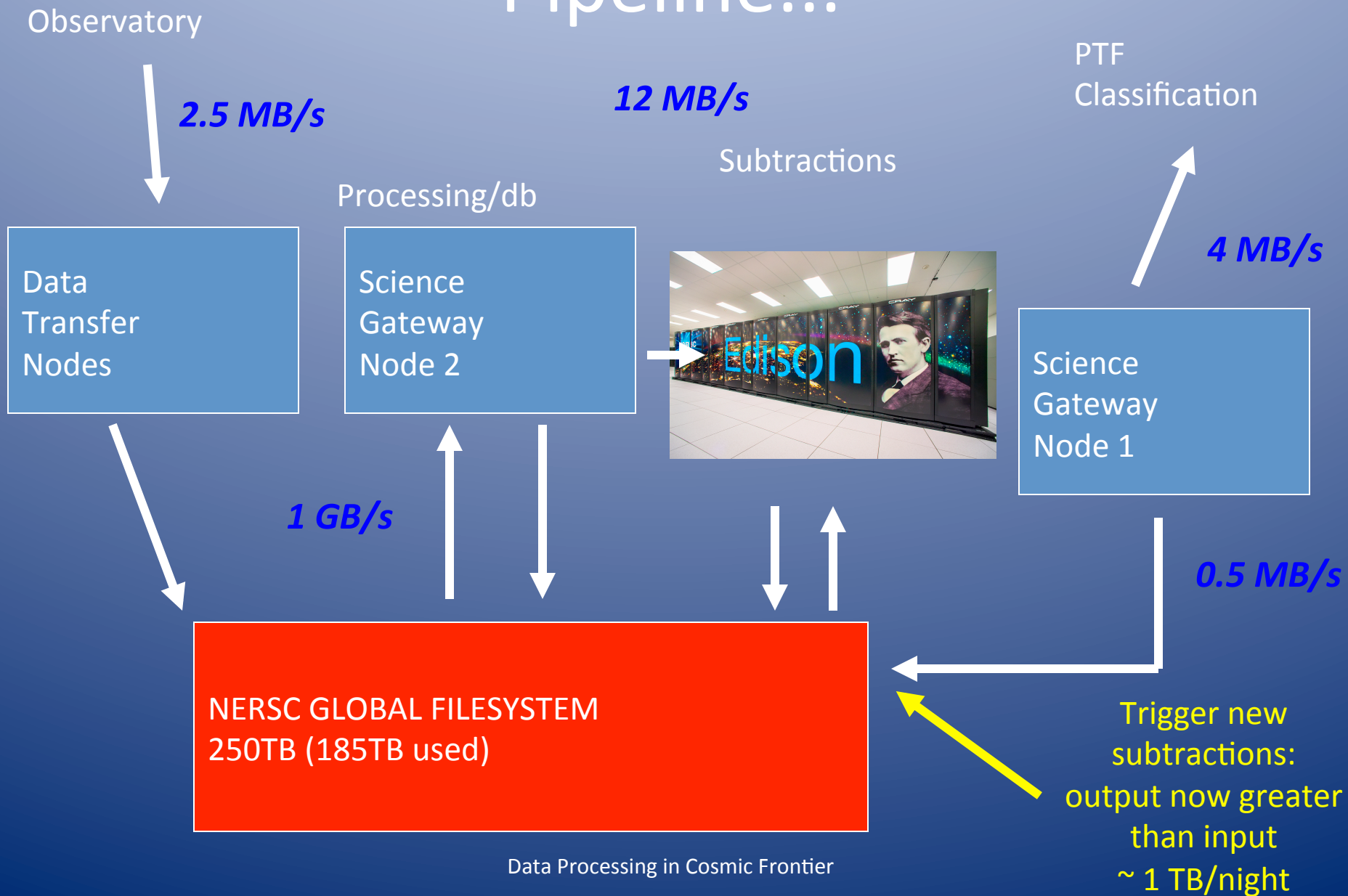
To date:

- 2338 Spectroscopically typed supernovae
- 10^6 Galactic Transients
- 10^4 Transients in M31

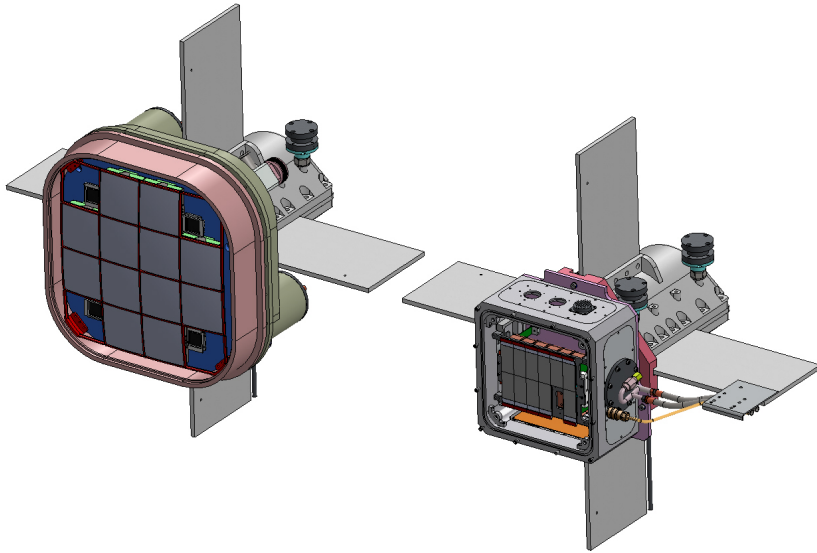
106 publications, 7 in *Nature* and 2 in *Science* since late 2009



Pipeline...



Future Surveys



ZTF (46 deg.²)

iPTF (7.2deg.²)

ZTF will be the largest imager until LSST

Telescope	$A\Omega$
<i>i</i> PTF/PTF	8.7
DES	11.7
ZTF	42.6
LSST	82.2



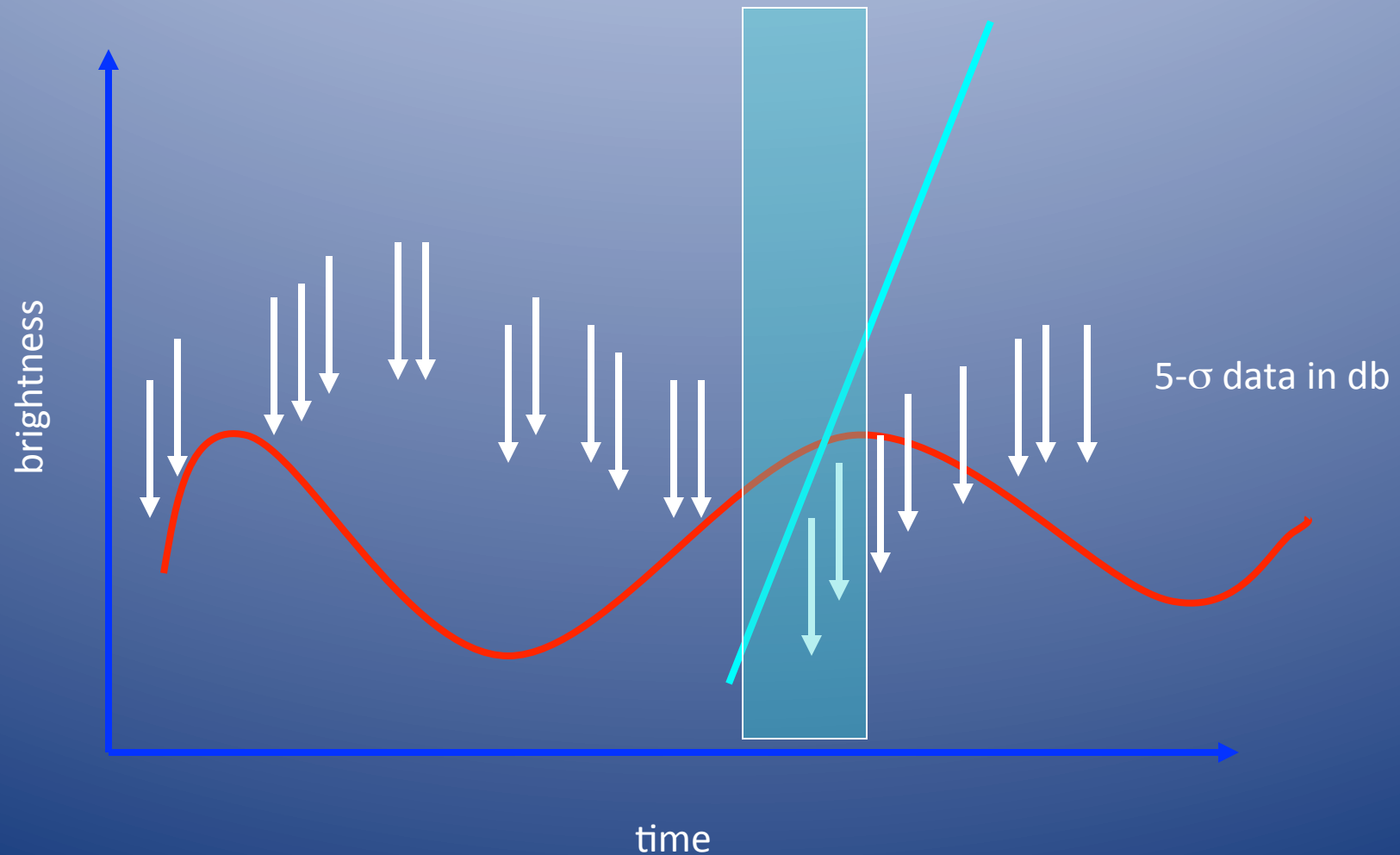
BlackGEM

BlackGEM

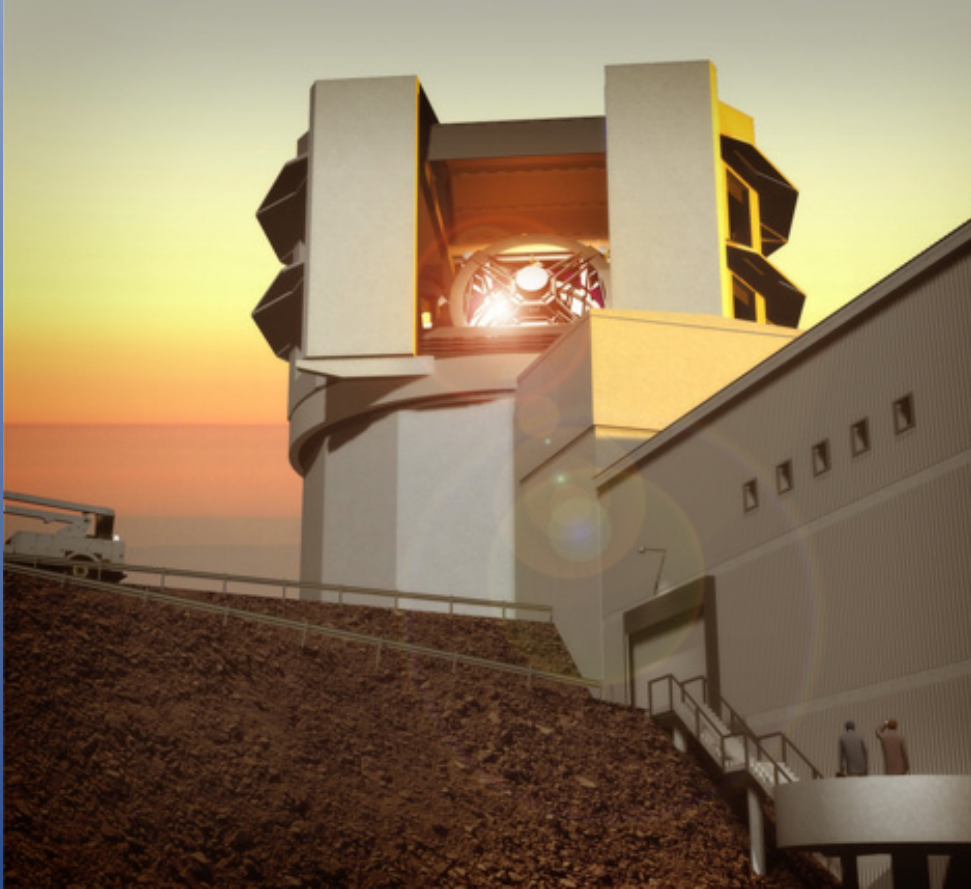
- Gravitational Wave follow-up.
- Poor localizations ~ 100 sq.deg.
- 15 X 0.6-m telescopes, each with a 10kX10k ccd imager, 2.7 sq.deg. each.
- 60-s images, need to work in near real-time.



Bottlenecks...crude vs. real



Future



LSST - 15TB data/night
Only one 30-m telescope
How many triggers can we handle???